S P E C I F I C A T I O N

Docket No. 00-C-015

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, Anthony M. Chiu, a citizen of the United States of America residing in the State of Texas, have invented new and useful improvements in a

SURFACE MOUNT PACKAGE FOR LINEAR ARRAY SENSORS

of which the following is a specification:

Fort Worth/1004KH-44054/79792.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates in general to packaging and mounting semiconductor devices and in particular to packaging and mounting semiconductor photo transmitter/receiver (transceiver) devices in linear arrays. Still more particularly, the present invention relates to packaging semiconductor devices in a linear array of photosensors having a total length much greater than the size of a substrate on which the devices are formed.

2. Description of the Prior Art:

The prevalence of imaging systems in contemporary consumer electronics relies in large measure on the fabrication of photosensors composed of charge coupled devices and CMOS devices. The charge coupled devices serve as photosensitive elements, with photons (light) impacting the surface of the charge coupled device creating charge at the terminals of the device. While a single sensing element detects light only at a single point, an array of sensing elements can detect variations of light reflected off an object being imaged as a function of position in a line or plane, enabling electronic encoding of a digital image of the object. Arrays of charge coupled devices find wide use in electronic products ranging from digital cameras to telecopier (facsimile or "fax") machines.

In some products, a linear array of photosensors detects a narrow line (often one or two pixels wide) of light reflected from the object being imaged. Moving the sensors

relative to the object and/or the object relative to the sensors by the width of the array creates an adjacent linear image, a process which may be repeated with the adjacent linear images (also called optical lines) combined to form a two-dimensional image. In the case of flat-bed scanners, the sensor array typically moves relative to the scanned page to capture the image, while fax machines generally move the paper across the sensors. Use of a linear array to capture two-dimensional images reduces system cost since fewer sensor units are required.

Linear arrays of photosensors are typically manufactured from strips of integrated circuits containing charge coupled devices and mounted on printed circuit boards. Currently, the integrated circuits are mounted in an unencapsulated silicon form, then connected to a power supply and other support electronics mounted on the printed circuit board through the use of gold bond wires. The bond wires are then protected utilizing liquid encapsulation or silicon gel. This technique, often referred to as "Chip On Board" technology, provides ease of manufacture in production of sensor arrays having charge coupled devices as well as other integrated circuit designs.

However, Chip On Board technology causes removal and replacement of a defective integrated circuit segment from a linear array to be prohibitively difficult. Simple removal of an integrated circuit segment from a linear array for replacement is simply not possible in an economical manner. An array containing a defective segment must therefore simply be discarded. As the length of linear arrays increases, and the array includes more integrated circuit segments, the likelihood of at least one segment being or becoming defective increases substantially. Therefore, maintaining an acceptable

yield in the linear array production constrains the length of arrays, a problematic limitation in that the number of parts and manufacturing steps in producing devices utilizing the linear arrays is increased. The limitation on array length also requires use of multiple linear arrays where designers would prefer a single linear array of greater length. Furthermore, multiple arrays must be aligned relative to each other during assembly.

It would be desirable, therefore, to produce linear arrays with greater length and more easily replaceable integrated circuit segments.

SUMMARY OF THE INVENTION

In linear arrays of charge coupled device photosensors, the sensor integrated circuits are contained in surface mountable packaging allowing individual segments to be soldered into place within the array. For solder-mountable packaging, unencapsulated sensor circuits are mounted onto a lead frame strip with the space between the circuits equaling the width of a singulation saw. After die mounting and wire bonding, a continuous strip of plastic or resin molding covers the wire bonds on one side and the edge of the silicon on the other, protecting the lead frame strip and other parts, leaving the active sensor area exposed. The lead frame is then trimmed and formed in a conventional manner, and the packaged sensor circuits are separated with a singulation saw cutting between the circuits. The resulting self-contained device may then be mounted within a linear array with solder rather than depending on Chip On Board technology. Leads are preferably soldered to the board on only one side, with the other side floating freely over the appropriate contacts for ease of mechanical adjustment. Individual sensor segments within the array may be readily removed and replaced in the event of a defect.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, and further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 depicts a pair of integrated circuit devices mounted on a lead frame strip, prior to completion of packaging, in accordance with the preferred embodiment of the present invention;

Figure 2 is a cross-sectional view of a mold and lead frame strip employed in packaging sensor circuits in accordance with a preferred embodiment of the present invention;

Figures 3A-3B depict plan and cross-sectional views of a packaged sensor device in accordance with the preferred embodiment of the present invention; and

Figure 4 is a plan view of several completed and packaged integrated circuit sensor devices mounted on a printed circuit board to form a linear sensor array in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION

The following description details the structure, application and features of the present invention, but it will be understood by those of skill in the art that the scope of the invention is defined only by the issued claims, and not by any description herein. The process steps and structures described below do not form a complete process flow for manufacturing integrated circuit packages. The present invention can be practiced in conjunction with integrated circuit package fabrication techniques currently used in the art, and only so much of the commonly practiced process steps are included as are necessary for an understanding of the present invention. The figures showing portions of an integrated circuit package during fabrication are not necessarily drawn to scale, but instead are drawn so as to illustrate the important features of the invention.

With reference now to the figures, and in particular with reference to **Figure 1**, a lead frame strip on which integrated circuit sensor devices are mounted, prior to completion of packaging in accordance with the preferred embodiment of the present invention, is depicted. In the figure, the integrated circuit sensor device die **104a-104b** are mounted on a metal alloy (typically either iron-nickel or copper based) lead frame strip **102** aligned collinearly along a centerline **106**, and contain conventional sensor devices for detecting variations in ambient light. The two integrated circuit sensor segments **104a-104b** are separated by a space **108** approximately equal to the kerf width of a singulation saw, about 50 microns. Charge coupled devices or other photosensitive devices are formed in a line along the length of the integrated circuit segments **104a-104b** up to the edges

of the respective die adjoining space **108**. Additional sensor device die (not shown) may be similarly mounted on the remaining portion of the lead frame strip **102**.

As in the conventional art, lead frame strip **102** may be formed by stamping and masked etching, and includes a plurality of lead frames each having centrally located supports **110a**, **110b** to which the integrated circuit die will later attach (commonly referred to as a "die paddle") and a network of leads **112**. Die paddles **110a** and **110b** are shorter in length than the integrated circuit die which will be mounted on the lead frames within lead frame strip **102**, so that spacing between adjacent integrated circuit die is limited by the length of the die. Metal strips (dam bars) **114**, located between the leads at points which will eventually lie just outside the edge of the completed molded packages, prevent molten encapsulant which seeps from the mold fixture from flowing out onto the leads and later adversely affecting lead trim and form operations. Additional bars (shorting bars) **116**, located between the lead tips, provide protection of the leads from mechanical damage during processing and handling. Generally a number of lead frames are temporarily connected together via larger shorting strips (bars) **118** to facilitate automated processing. Alignment or "tooling" holes **120** in the lead frame strip **102** allow for automated handling, attachment of the remaining parts of the circuit to the lead frame, and encapsulation of the mounted die **104a-104b**.

Integrated circuit die **104a-104b** are affixed to the die paddles **110a-110b** of the lead frame utilizing an adhesive, such as polymers (including resin-based epoxies and

polymides), solder, or gold eutectic. Integrated circuit die **104a-104b** are mounted with a separation approximately equal to a kerf width of a singulation saw which will be used to separate packaged integrated circuits. Once each integrated circuit die **104a-104b** is affixed to the lead frame strip **102**, wire bonding will typically create connections between bond pads on the integrated circuit surface and leads **112** providing electrical connection to outside electronic parts. Small gold wires are welded or soldered (usually thermosonic gold wirebonding) between bond pads and selected leads **112** to create "pins" for the completed, packaged circuit.

Referring to **Figure 2**, a cross-sectional view of a mold and lead frame strip employed in packaging sensor circuits in accordance with a preferred embodiment of the present invention is illustrated. The figure illustrates a cross-section of lead frame strip **102** depicted in **Figure 1** taken at section lines **A-A** and of a mold when the lead frame strip **102** is mounted to the mold **200** for encapsulation of the integrated circuit die **104a**. When lead frame strip **102** with integrated circuit die **104a** is mounted to mold **200**, a portion **202** of the mold **200**, about 100-200 μm in width, abuts the surface of integrated circuit die **104a** on which the photosensitive devices are formed, preventing the encapsulating material from forming on that portion of the integrated circuit die surface and leaving that portion exposed. In general, this part of the mold that is in contact with the silicon chip surface is made from soft material such as silicone rubber or cushioned by a polyimide film. Portion **202** of mold **200** extends to an edge of the integrated circuit die **104a**, and a sloped surface of mold **200** provides a mold cavity region in which wire bonds

may be encapsulated. The cavity includes several similar regions for receiving each integrated circuit die and attached bond wires which are affixed to the lead frame strip. Mold **200** also includes tooling pins **204** projecting from a surface adjacent the mold cavity region and received by tooling or alignment holes **120** within the lead frame strip **102**.

Lead frame strip **102** and integrated circuit die **104a** are then molded with a thermosetting resin or thermoplastic injected into the open spaces of mold **200**, covering a portion of the lead frame **102** and the integrated circuit die **104a** except for the surface abutting mold portion **202**. The plastic or resin will also cover bond wires and will adhere to the surfaces of all of the parts exposed to the resin, further securing the integrated circuit to the lead frame. The sensor portion on which the charge coupled devices which actually receive the photon are formed, however, will remain uncovered, allowing light from the object being imaged to reach the photosensors. Various encapsulation processes (including transfer molding, injection molding, and reaction-injection molding) may be employed.

After the formation of the epoxy or plastic covering using mold **200**, the lead frame strip **102** trim and form operations commence to create connections easily available in mounting the integrated circuit device to other pieces of electronic equipment. Singulation is performed by sawing through the packaging and lead frame strip between the integrated circuit die **104a** and **104b** within the gap **108** left for that purpose.

With reference now to **Figures 3A** and **3B**, plan and cross-

sectional views of a packaged sensor device in accordance with the preferred embodiment of the present invention are depicted. The packaged device contains the integrated circuit sensor device with a sensor region **302** exposed, not covered by the packaging plastic or resin **304** which otherwise encapsulates the integrated circuit die, the portion of the lead frame to which the sensor die is affixed, and the bond wires and adhesive connecting the sensor die to the lead frame.

The packaged integrated circuit also includes leads **306** on one side and leads **308** on the other. In the assembled linear array, one set of leads **306** is preferably soldered into place while the other set **308** floats freely over the contacts to provide ease of mechanical adjustment in the finished array. Solder around the soldered leads **306** may be reflowed to allow removal of defective finished packages from the array.

Referring to **Figure 4**, a plan view of several completed and packaged integrated circuit sensor devices mounted on a printed circuit board to form a linear sensor array in accordance with a preferred embodiment of the present invention is illustrated. A printed circuit board **400** is shown on which several completed circuit packages **402a-402h** are mounted, with the exposed region of each package aligned. Errors in alignment may be offset by control circuitry or software compensation. As noted above, preferably leads on one side of each package **402a-402h** are soldered while leads on the other side remain in floating contact with conductive structures on the printed circuit board **400**. Alignment may be

adjusted by "floating" the soldered leads. The minimum possible space between each pair of adjacent packages **402a-402b**, **402b-402c**, **402c-402d**, **402d-402e**, **402e-402f**, **402f-402g**, and **402g-402h** within the linear array is maintained, preferably with adjacent packages in contact with each other if possible so that less than one pixel width of dead space is created between discrete linear array packages. Even with automated mounting of packages **402a-402h** on circuit board **400**, spacing of less than 10 microns between adjacent packages should be possible, and image correction and extrapolation algorithms may be employed to derive image data for portions of optical lines which are not directly imaged due to such spacing. A 10 μm pixel is equivalent to 2540 dpi (dots per inch). For fax machines and other coarse scanning devices, such spacing is adequate to provide satisfactory imaging resolution. Alternatively, two lines of staggered packages may be mounted on the circuit board **400** to obtain greater resolution.

The present invention allows individually packaged integrated circuit sensor segments within a linear array to be easily removed by soldering the segments into place on the circuit board rather than affixing the sensor segments to the board with a silicon gel or liquid encapsulation coating. Replacement of a single segment after discovery of a defect is thus enabled. Since the cost of replacing a single integrated circuit package is far less than the cost of discarding an entire linear array containing a single defective sensor segment, the present invention should allow for the construction of far longer linear arrays, and high resolution arrays of multiple rows.

While the invention has been particularly shown and

described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.